

Design of Shear Walls in Response Spectrum method and to Study Effect of Vertical Stiffness Irregularity on Multi-Storey

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ABSTRACT: Urbanization has led to real estate problems that led to the rise of several Highrise and Multi-storey buildings. Hence Structural Dynamics analysis has been continuously increasing over the years. Shear wall is actually a fundamental essential structural component. the walls could be used for giving safety and strength more to the structure, when the structures are actually put through external loads, like earthquake loads, wind lots etc. the kind of walls, essentially play a primary role for the building of tall structure. With this paper, a ten storey developing in Zone IV is actually presented to bring down the outcome of earthquake utilizing reinforced concrete shear wall framed buildings in the construction. The results were tabulated by executing Response spectrum analysis using ETABS model 9.7.4 in the type of optimum storey displacements, base shear reactions, storey drifts and mode shapes. Effect of Irregularity was studied by producing openings in shear wall structure and also by varying the thickness of Shear wall, along the storey's.

KEYWORDS: Base Shear, Multi-storey Buildings, Response Spectrum Analysis, Seismic loading

I. INTRODUCTION

In general, the term infill frame is used to denote a composite structure formed by the combination of a moment resisting plane frame and infill walls. It can be comprehended that if the impact of infill is considered in the analysis and design of frame, the subsequent structures may be altogether diverse. In this manner, a study is attempted which will include the limited component analysis of the conduct of reinforced concrete (RC) frame with brick masonry infill. Again when a sudden change in stiffness happens along the building stature, the story at which this uncommon change of stiffness happens is known as a soft storey. A soft story is the one in which the lateral stiffness is under 70% of that in the story above or under 80% of the normal stiffness of the three stories above. Social and functional needs like vehicle parking, shops, reception etc. are compelling to provide soft storey in high-rise building. In the present study, seismic execution of 3D building frame with transitionally infill frames and shear wall at different positions was considered. Performance of R.C. frame was evaluated with ground soft storey and asymmetric in elevation of building with distinctive arrangement. The primary objective of the study is to examine the behavior of multistory, multi-bay with ground soft storey R C frames with and without infill's, also with shear wall at various positions, and to evaluate their functioning levels when subjected to seismic loading. In this thesis, hypothetical multistoried R C buildings with ground soft storey (i.e., eleven storied with and without infill) found in zone IV of hard soil site has been analyzed and designed for load combinations given in code where pushover analysis is used for evaluation purpose.

II. RELATED WORK

Venkata Sairam Kumar. N & et al (February 2014) carried out research mainly on application of cyclic load tests and behaviour of different types of shear walls in cyclic application of loads. Shear walls can be used as lateral load resisting Systems and also retrofitting of structures. Internal shear walls are more efficient than External shear walls when compared with cyclic load tests by researchers.

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 5, Special Issue 9, May 2016

Ravikanth Chittiprolu, Ramacharla Pradeep Kumar, (June 2014) performed study on dynamic linear analysis using response spectrum method and lateral load analysis was done for structure with shear wall and structure without shear wall. Results were compared for the frame lateral forces and storey drifts of both the cases. It was inferred that shear walls are more resistant to lateral loads in an irregular structure. Storey drift is reduced in case of structure with shear wall. Also they can be used to reduce the effect of torsion.

Varsha R. Harne (2014) carried out a study to determine the strength of RC Shear wall of a multi-storied building by changing shear wall location. 3 different cases of shear wall position for a 6 storey building have been analysed. Incorporation of shear wall has become inevitable in multi-storey building to resist lateral forces. Among all the load combination, the load combination of 1.5 DL 1.5 EQX is found to be more critical combination for all the models. It was found that shear walls are more effective when located along exterior perimeter of the building. Such a layout increases resistance of the building to twisting.

Shaikh Abdul Aijaj, Abdul Rahman & Girish Deshmukh (2013), made attempts to investigate the proportional distribution of lateral forces evolved through seismic action in each storey level due to changes in stiffness of frame on vertically irregular frame.

S.Kumbhare, A.C. Saoji (2012) had carried out study on the effect of seismic Loading on placement of shear wall in medium rise building at different alternative location. They found that frame type structural system becomes economical as compared to dual type structural system and can be used for medium rise residential building situated in high seismic zone.

Ashish S. Agrawal, S.D.Charkha (2012) carried out study on 25storey building in Zone V by changing various position of shear wall with different shapes for determining parameters like storey drift, axial load and displacement. From the results of analysis they came to a conclusion that placing shear walls away from centre of gravity resulted in increase in most of the member forces. Also they found that displacement of the building floor at storey 25 has been reduced due to the presence of shear wall place at the centre.

Y.M. Fahjan & J. Kubin & M.T. Tan (2010) found that in the countries with active seismicity, reinforced concrete structural walls are widely used in multi-storey structure systems. Therefore, a proper modelling of the shear walls is very important for both linear and nonlinear analyses of building structures. The shell element can be used efficiently for the analysis of building structures with shear walls. The shell element considered in most of the design software has 6 degrees of freedom at each node and an in-plane rotational degree of freedom, which makes it compatible with three-dimensional beam-type finite element models. Shear wall modelling requires mesh discretization in order to get realistic behaviour. The advantage of using shell elements is the ability to model very long, interacting and complex shear walls within the three dimensional model.

G. Nandini Devi, K.Subramanian & A.R.Santhakumar (June 2009) studied a three bay R.C frame without and with shear wall in middle bay which was subjected to static cyclic lateral load. Shear wall of one bay was subjected to static reversed cyclic lateral load to assess its individual behaviour. Cyclic effects on the shear wall frame were considered for comparison. Shear wall frame and dual frame was compared to assess the individual behaviour of shear wall and when it is designed with beam column Frame. It was found that in spite of carrying large load, the dual frame exhibited less top storey deflection. At the initial stage of loading the dual frame was 7.84 times stiffer than the bare frame and 4.84 times higher than the shear wall frame. At service load (50% of the ultimate load, the dual frame is 10.56 times stiffer than the bare frame and 6.76 times stiffer than the shear wall frame. When the frames are compared at service load, it was found that the dual frame can be used for a larger service load and can withstand higher seismic loads with small deflection.

J.Kubin, Y.M.Fahjan and M.T.Tan (2008) studied the different approaches of modelling the shear walls in structural analyses of buildings and compared their results. The shear walls within the building structures are generally modelled by either a composition of frame elements or a mesh of shell elements. In modelling shear walls with shell elements the

International Journal of Innovative Research in Science, Engineering and Technology

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drilling moment of the shear walls and the bending moment of the in-plane connected beams are changed dramatically with mesh density. For finer meshes, 10% reduction of the drilling moment can be estimated. Introduction of top Chord frame stabilize the results considerably. Good estimation of the properties of the top chord frame is very important to not affect the overall stiffness of the structural system. Best results are obtained using a top chord frame element to enhance the fixity of the beams framing into the shear wall.

III. DESIGN METHODOLOGY

The current study is actually an attempt in the state of art form of seismic analysis of multistoried RC buildings. The emphasis of interest is actually finding the performance level of the structure with the assistance of demand and capacity of the construction for created earthquake utilizing nonlinear fixed pushover analysis, during the end suitable arrangement of construction to be being used is actually suggested.

A. Building and Loading

1. The study is actually finished by looking to buy a reinforced concrete frame business building resting on isolated footing.
2. Considering parabolic ton pattern seismic force is actually applied.

B. Modeling as well as Analysis Method

1. 3-Dimensional modelling for investigations utilizing ETABS
 2. The structure is actually examined by Equivalent static, Response Spectrum also as Pushover analysis.
 3. The building models are actually impelled along good orthogonal directions.
- The peak or perhaps optimum effect (acceleration, velocity, displacement) of all the potential linear single amount of independence (SDF) system to a specific part of ground activity for a specified amount of damping.

C. Applications of the result spectrum

- a. The response spectrum offered a practical and convenient method to summarize the frequency articles of a certain acceleration, velocity or maybe displacement time history.
- b. It offers a useful method to use the expertise of structural dynamics to look of development and structures of lateral force needs in building codes.

D. Types of Response Spectra

- a. Response Spectra estimated from real time histories: Steps for calculating a result spectrum from a period history
The result spectrum for a specified ground movement component (e.g., $a(t)$) is actually made using the following steps:
 - (1) Obtain the ground movement ($a(t)$) for an earthquake. Typically the acceleration values ought to be identified at time measures of 0.02 next, or perhaps less.
 - (2) Select the organic vibration phase, T_n , and damping ratio, α , for SDOF system. (Usually five % damping is actually selected.)
 - (3) Determine the highest displacement reply for a SDOF system with the selected % damping for a specified frequency or period of vibration.
To do this, you have to fix the following differential equation $mM2u/dt2 + c Mu/dt + k u = F(t)$
 - (a) Closed type remedy (linear systems)! Answer is just valid for first conditions at rest
 - (b) Duhamel's important (linear systems)! grounded on managing the regular activity as a series of short impulses
 - (c) Frequency Domain technique (linear systems)! Fourier transform
! Inverse Fourier transform
 - (d) Numerical strategies (nonlinear and linear systems)! Numerical time stepping methods
 - (4) Repeat step three and change the important period of the framework by altering the mass (m), the stiffness (k), or perhaps both. Plot the brand new results.

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Vol. 5, Special Issue 9, May 2016

E. Response Spectrum Method

To be able to do the seismic analysis and look of a framework to be constructed at a certain area, the real time history record is needed. Nevertheless, it's not feasible to get such records at every single location. Additionally, the seismic evaluation of buildings can't be carried out just depending on the peak value of the soil acceleration as the result of the framework rely upon the frequency articles of terrain movement and its unique powerful properties. To get over the above mentioned difficulties, earthquake reply spectrum is regarded as the popular application in the seismic evaluation of buildings. There are actually computational benefits in utilizing the reaction spectrum technique of seismic evaluation for prediction of displacements as well as part forces in structural methods. The technique consists of the calculation of just the optimum values of the displacements as well as member forces in each method of vibration by using sleek style spectra that are actually the typical of several earthquake motions. It is going to deal with response spectrum technique and the application of its to different kinds of the structures. The codal provisions as per is actually: 1893 (Part 1) 2002 code for reaction spectrum analysis of multi-story development is also summarized.

IV. RESULTS AND DISCUSSIONS

General

- a) Material used was M25 Grade Concrete.

Analysis Property Data

- b) Yield stress $f_y = 415 \text{ N/mm}^2$
c) Compressive Cube Strength of Concrete = 25 N/mm^2
d) Poisson's ratio = 0.2
e) Analysis was done using ETABS Software 9.7

1) Building Details

Type of frame: Special RC moment resisting frame fixed at the base

Seismic zone: IV

Number of storey: G+9

Floor height: 3.0 m

Depth of Slab: 120 mm

Size of beam: (250 × 450) mm

Size of column: (300 × 450) mm

Spacing between frames : (i) 6 m in X & Y direction (General), (ii) 24 m × 15 m in X & Y direction

Live load on floor: 2 kN/m^2

Floor finish: 1.5 kN/m^2

Wall load: 14 kN/m

Materials: M 25 concrete, Fe 500 steel Material

Thickness of wall: 230 mm

Thickness of shear wall: 150 mm

Density of concrete: 25 kN/m^3

Density of masonry wall: 19 kN/m^3

Type of soil: Medium

Response spectra: As per IS 1893(Part-1):2002

Damping of structure: 5 percent

Seismic Analysis

Earlier, the buildings were designed just for gravity loads but in recent times, Seismic analysis is a major tool in earthquake engineering used to understand the response of buildings due to seismic excitations in a simpler manner. Different types of earthquake analysis methods are: Equivalent Static Analysis, Response Spectrum Analysis, and Time History Analysis

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 5, Special Issue 9, May 2016

Response Spectrum Analysis

This approach permits the multiple modes of response of a building to be taken into account. For each mode, a response is obtained from the design spectrum, corresponding to the modal frequency and the modal mass, and then they are combined to estimate the total response of the structure. Following are the types of combination methods:

(a) Absolute - peak values are added together, (b) Square root of the sum of the squares (SRSS), (c) Complete quadratic combination (CQC) - a method that is an improvement on SRSS for closely spaced modes.

Model Showing Different Types of Irregularities

Plan, stiffness and Vertical Geometric Irregularity are shown in Fig. 1.1, 1.2 & 1.3

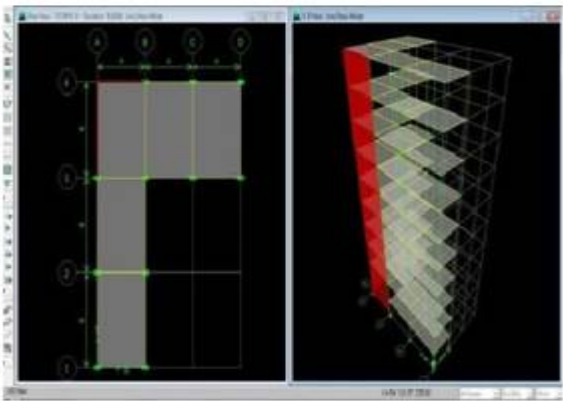


Fig. 1.1 showing Plan Irregularity – L shaped

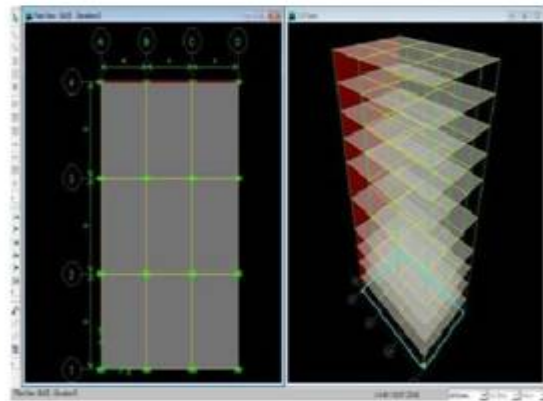


Fig. 1.2 showing Stiffness Irregularity

Plan Irregularity is shown in Fig. 1.1 & in Fig. 1.2, height of the storey is varying. It is called as soft storey. Buildings on Stilts will fall under this category.

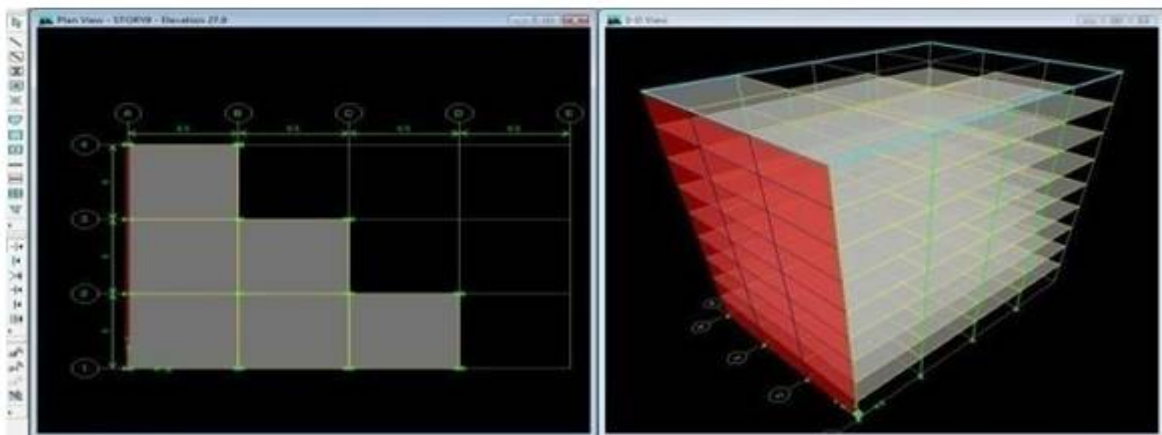


Fig. 1.3 showing Vertical Geometric Irregularities

Vertical Geometric Irregularity is shown in Fig. 1.3. A vertical setback is a geometric irregularity in a vertical plane. The setback can be visualized as a vertical re-entrant corner.

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Vol. 5, Special Issue 9, May 2016

Comparison of Models for Regular configuration Shear Walls

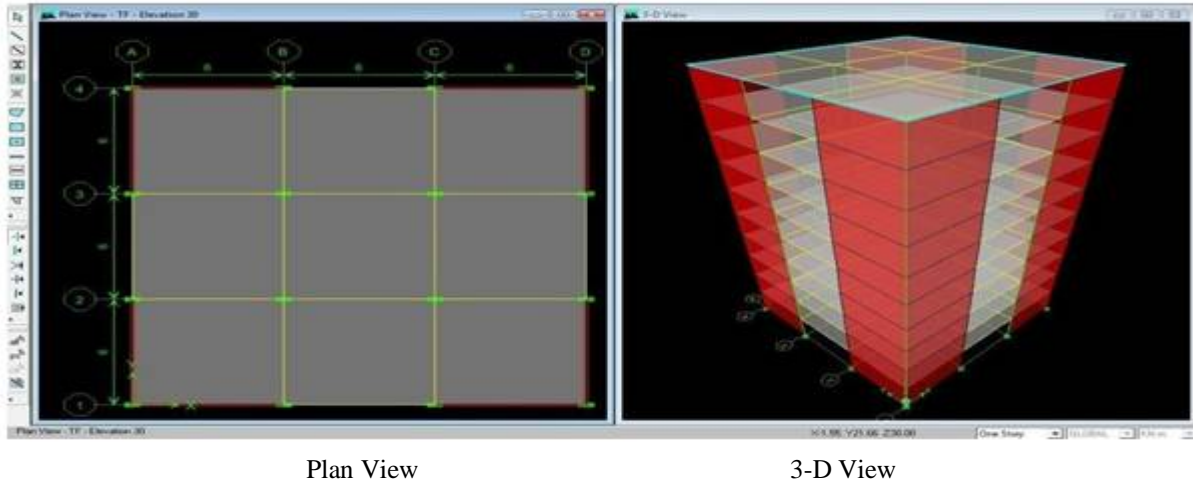


Fig. 1.4 showing G + 9 Storey Building with Shear wall

G+9 Regular Building with/without Shear walls is shown in Fig. 1.4 &1.5. Shear walls are vertical elements of the horizontal force resisting system. They are designed not only to resist gravity / vertical loads (due to its self-weight and other living / moving loads), but also for lateral loads of earthquakes / wind. The walls are structurally integrated with roofs / floors (diaphragms) and other lateral walls running across at right angles, thereby giving the building structures three dimensional stability.

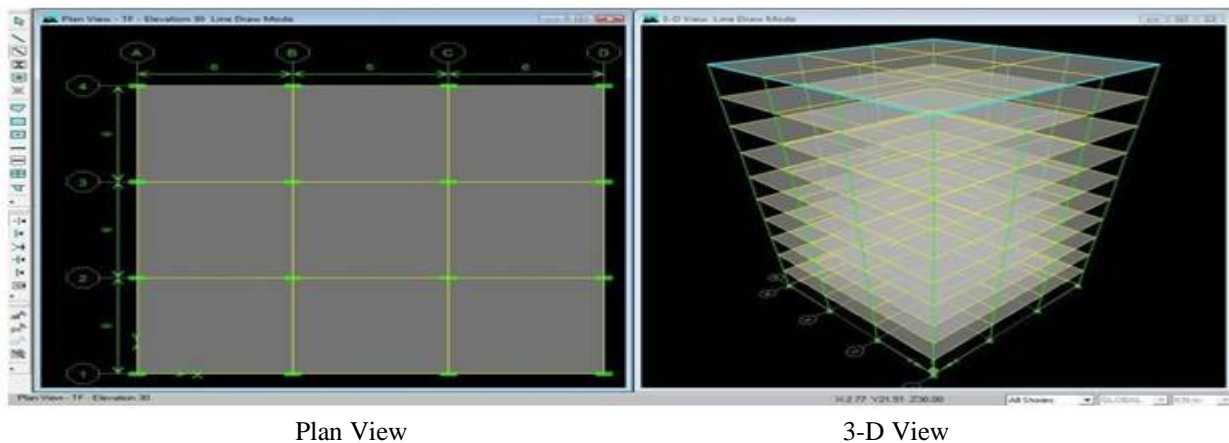


Fig. 1.5 showing G + 9 Storey Building without Shear Wall

Shear walls is quick in construction, because concreting of the members is done using formwork. Since Shear walls give such a high level of precision, it doesn't require any extra plastering or finishing.

Comparison of Models for Irregular configuration with openings in Shear wall / without openings in Shear Walls

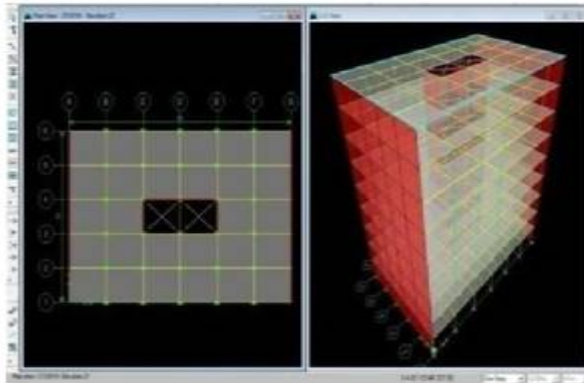


Fig. 1.6 showing G + 9 Storey Building openings

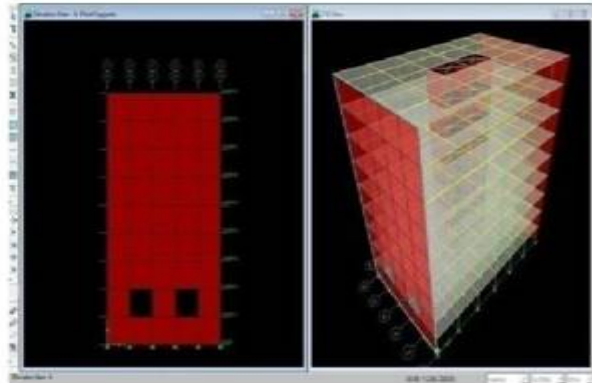


Fig. 1.7 showing G+9 Storey Building with Without Shear Wall Shear wall opening in the Second Storey

Building with G+9 Storey's showing Shear wall without any opening/with opening in 2nd storey are shown in Fig. 1.6 & 1.7. As per IS: 1893 (Part 1 2002, Table 8 Percentage of Imposed Load to be Considered in Seismic Weight Calculation (cl. 7.3.1) Imposed load considered for the G+9 Storey Building was taken as 3 kN/m^2

V. CONCLUSIONS

From the results it's inferred that shear walls are far more reluctant to lateral loads in regular/Irregular framework. The moments in the columns got reduced when shear wall structure is actually created in the framework. The highest storey displacement of the structure is actually cut back by fifty % when shear wall is actually provided. Probably the highest deformed shape is shown by mode shape two. Shear wall with openings and with different thickness is stable and strong still adequate to withstand seismic loads. For more secure style, the thickness of the shear wall must range between 150mm to 400mm. Shear walls in structures should be symmetrically located in approach to decrease ill effects of twist in buildings. They need to be put symmetrically along one or even both directions in approach.

REFERENCES

- [1] Venkata Sairam Kumar, Surendra Babu.R, Usha Kranti.J; Shear walls – A review, International Journal of Innovative Research in Science, Engineering and Technology, Vol. 3, Issue 2, February 2014.
- [2] Konuralp Girgin and Kutlu Darılmaz; Seismic Response of Infilled Framed Buildings Using Pushover Analysis, ARI The Bulletin of the Istanbul Technical University, Volume 54, Number 5.
- [3] Qihong Zhao and Abolhassan Astaneh-Asl, M; Cyclic Behavior of Traditional and Innovative Composite Shear Walls, Journal of Structural Engineering © ASCE / February 2004 / 271-284.
- [4] E. Giuriani, M. and A. Gubana, M; Underground Box Structure as a Foundation for Shear Walls in Seismic Resistant Buildings, Journal of Structural Engineering © ASCE / April 2007 / 559-566.
- [5] Vikas Govalkar, P. J. Salunke, N. G. Gore; Analysis of Bare Frame and Infilled Frame with Different Position of Shear Wall, International Journal of Recent Technology and Engineering (IJRTE) ISSN: 2277-3878, Volume-3 Issue-3, July 2014.
- [6] Prof. Milind V. Mohod; Pushover Analysis of Structures with Plan Irregularity, IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 12, Issue 4 Ver. VII (Jul. - Aug. 2015), PP 46-55.
- [7] P. P. Chandurkar, Dr. P. S. Pajgade; Seismic Analysis of RCC Building with and Without Shear Wall, International Journal of Modern Engineering Research (IJMER) Vol. 3, Issue 3, May-June 2013, pp-1805- 1810 ISSN: 2249-6645.
- [8] Mr. Syed Owise Showkath Peer, Khalid Nayaz Khan; Seismic Vulnerability of RC Buildings by Considering the Effect of Shear Wall, International Journal of Scientific Research, Volume 3, Issue 9, September 2014, ISSN No 2277 – 8179.
- [9] Ashok Thakur, Arvinder Singh; Comparative Analysis of a Multistoried Residential Building with and Without Shear Wall using STADD Pro., International Journal of Recent Research Aspects ISSN: 2349-7688, Vol. 1, Issue 1, June 2014, pp. 54-57.
- [10] Dhileep M, Trivedi A and Bose P R, Behavior of high frequency modal responses in nonlinear seismic analysis, International Journal of Civil and Structural Engineering, Volume 1, No 4, 2011.



ISSN(Online) : 2319-8753
ISSN (Print) : 2347-6710

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Special Issue 9, May 2016

- [11] A. Shuraim and A. Charif, Performance of Pushover procedure in Evaluating the Seismic Adequacy of Reinforced Concrete Frame, 7th Saudi Engineering Conference.
- [12] Xiao Kang ZOU and Chun Man CHAN, Seismic Drift Performance Based Design Optimization of Reinforced Concrete Buildings, 13th World Conference on Earthquake Engineering, Vancouver, B.C. Canada, August 1-6, 2004, Paper No.223.